

**REVERSE FLOW AIR FILTER ARRANGEMENT AND METHOD****Cross-Reference to Related Applications**

5           The present application is a continuation-in-part  
application of U.S. serial no. 08/742,244, filed  
October 31, 1996. U.S. serial no. 08/742,244 was a  
divisional of U.S. serial no. 08/344,371, filed  
November 23, 1994. The complete disclosure of application  
10 U.S. serial no. 08/742,244 is incorporated herein by  
reference. Application serial no. 08/344,371 issued on  
March 25, 1997 as U.S. Patent 5,613,992. The complete  
disclosures of U.S. Patent 5,613,992 and the application  
which issued as the '992 patent are also incorporated  
15 herein by reference.

**Field of the Invention**

          The present invention relates to reverse flow air  
cleaner arrangements. That is, the invention concerns air  
20 cleaner arrangements wherein filtering flow is in a  
direction with the "clean" side of the air filter being  
around an exterior thereof, and the "dirty" side of the air  
filter being along an interior thereof. The invention  
particularly concerns such air cleaner arrangements having  
25 drainage systems for water accumulating in an interior of  
associated air filter elements. The invention also  
concerns provision of preferred components, such as air  
filter elements, for use with such arrangements; and, to  
methods involving the use of such arrangements.

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Consider, for example, a reverse flow air cleaner arrangement, having a cylindrical air filter element, utilized on an over the highway truck. Air directed into

10 interior of the filter element.

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Summary of the Disclosure of U.S. Serial No. 08/742,244

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In certain preferred arrangements, according to the U.S. serial no. 08/742,244 disclosure, the second end

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5 housing, without interference with the seal between the second end cap and the housing. This is facilitated by those arrangements involving provision of the seal along an annular portion of the end cap, as a radial seal, rather than as an end or axial seal.

10           According to the U.S. serial no. 08/742,244  
disclosure, preferably the second end cap outer surface is  
configured to provide a funnel surface having a declination  
angle of at least about 1°, and preferably 1° to 3°, in the  
region of extension between the outer edge of the second  
15 end cap and the portion of the end cap which engages the  
seal bead in the base.

In preferred arrangements, according to the U.S. serial no. 08/742,244 disclosure, an evacuation valve is mounted in the drainage aperture of the recessed pan in the 20 base. This provides for a preferred, controlled, drainage of moisture from the system.

In preferred embodiments, according to the U.S. serial no. 08/742,244 disclosure, a soft polymeric material is utilized for the first and second end caps. Preferably each of the polymeric end caps comprise polyurethane. For the end caps, a polyurethane foam material having an "as molded" density of about 14-22 lbs per ft<sup>3</sup> will be preferred (most preferably about 18.4). In some

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According to the U.S. serial no. 08/742,244 disclosure, a preferred filter element is provided. The preferred filter element comprises a generally cylindrical extension of filter media. The filter media may be, for example, a pleated paper filter media. Preferably, an inner support liner and an outer support liner are provided, for the cylindrical extension of filter media. Preferably the arrangement has first and second end caps, the first end cap including an air inlet opening therein. The second end cap preferably has a central drainage aperture and an interior surface constructed and arranged to funnel moisture, collected on the interior surface of

the second end cap, to the central drainage aperture. The central drainage aperture is preferably located at an approximate center of the end cap, on a longitudinal axis of the cylindrical extension of filter media. A preferred configuration for the interior surface of the second end cap, is as an interior of a funnel. In some embodiments, the second end cap interior surface includes a plurality of radially directed troughs therein, which terminate at the central drainage aperture.

10 Other preferred features for the preferred air filter element described in the U.S. serial no. 08/742,244 disclosure include: a circular sealing trough on an outer surface of the second end cap; and, a recess between an outer edge of the end cap outer surface and the circular  
15 trough. Also, a compressible region providing for a radial seal along an annular portion of the second end cap is preferred.

According to the U.S. serial no. 08/742,244 disclosure, a method of operating a reverse flow air filter  
20 arrangement is provided. In general, the method comprises collecting moisture within the filter element and draining the moisture from the filter element through a central aperture in the end cap, by funneling the moisture to the central aperture.

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#### Summary of the Present Disclosure

According to the portion of the present specification which comprises added disclosure relating to

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Figs. 9-14, the end cap which includes the drainage aperture therein, is provided in a preferred composite structure. The composite results from an outer portion comprising a soft, compressible, polymeric material; and, 5 an inner "pre-form" or insert, which becomes positioned between the polymeric material and the inner liner, during molding. The insert has preferred inner surface characteristics, to accomplish desirable flow of liquid to the drainage aperture, and outwardly from an interior of 10 the filter element. In addition, it has preferred features to facilitate molding using a free rise technique.

The preferred "pre-form" or insert also has depending legs with outwardly projecting feet. The legs and feet operate, cooperatively, as a mold stand-off for 15 media. An underside of each foot has a bead thereon, to facilitate this.

Further features and advantages from the preferred inserts and "pre-forms" described herein, as well as techniques for use, will be apparent from the more 20 detailed description below.

#### **Brief Description of the Drawings**

Fig. 1 is a side elevational view of an air cleaner arrangement according to the present invention.

25 Fig. 2 is a top plan view of the arrangement shown in Fig. 1.

Fig. 3 is an exploded plan view of the arrangement shown in Fig. 1.

Fig. 5 is a fragmentary cross-sectional view of a portion of the arrangement shown in Fig. 1; Fig. 5 generally being taken along line 5-5, Fig. 1.

10            Fig. 7 is a fragmentary top plan view of a  
portion of the arrangement shown in Fig. 6.

Fig. 9 is a fragmentary cross-sectional view of a 15 second alternate embodiment of the present invention, taken from a point of view analogous to that used for Fig. 5.

Fig. 11 is a cross-sectional view of the  
20 component depicted in Fig. 10, taken along line 11-11  
thereof.

Fig. 13 is a fragmentary schematic representation  
25 of a cross-section of a mold configuration usable to  
generate the assembly of Fig. 9.

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Disclosure of U.S. Serial No. 08/742,244 and Its Parent  
U.S. Serial No. 08/344,371

10           The reference numeral 1, Fig. 1, generally designates an air cleaner assembly according to the disclosure of serial no. 08/742,244. Fig. 1 is a side elevational view of air cleaner assembly 1. In the Figure, housing 2 is depicted generally. The housing 2 includes an inlet construction 3 and a filter element receiver or can 4. Can 4 includes outlet 7. In use, air to be filtered passes through inlet construction 3, and is directed to an interior of can 4. Within can 4, the air is directed through a filter element, not viewable in Fig. 1.

20 After being filtered by the filter element, the air passes outwardly through outlet 7 and is directed to the air intake of the engine, not shown. Herein, the term "air flow direction arrangement" is used to generally refer to those features of an air filter arrangement which direct

25 air flow in the preferred manner or along a preferred path. The term may refer to a variety of features, and typically refers to internal configurations of the housing and filter element, as well as the various seals.

Still referring to Fig. 1, inlet construction 3 is mounted on can 4, and is secured thereto by bolts 8 and nuts 9. Access to the interior of can 4, and a filter element positioned therein, is obtained by loosening 5 bolts 8 and separating inlet construction 3 from can 4.

For the particular construction shown, inlet construction 3 includes an upper dome 12, perforated air inlet screen 13 and an inlet tube 14 (the inlet tube not being viewable in Fig. 1, but being shown in Fig. 4 in 10 cross-section).

Still referring to Fig. 1, can 4 includes a drainage aperture therein, the drainage aperture not being viewable in Fig. 1, but being shown at reference numeral 18 in Fig. 5. The drainage aperture is covered by an 15 evacuation valve 19. The evacuation valve 19 may be, for example, as described in U.S. Patent 3,429,108, the disclosure of which is incorporated herein by reference. In general, the drainage aperture 18 is positioned in a portion of can 4 which will be, when assembly 1 is 20 operatively installed, positioned at the bottom of the assembly 1. Thus, water will tend to collect near aperture 18, and be drained therefrom, in use. This will be more readily apparent from further descriptions wherein internal details of air cleaner assembly 1 are presented.

25 Referring to Fig. 2, air cleaner assembly 1 includes four bolts and nuts 9 for securing the inlet construction 3 to the filter can 4. While the number of bolts used may be varied, depending on the particular

An exploded view of air cleaner assembly 1 is depicted in Fig. 3. In Fig. 3, air cleaner assembly 1 is shown with inlet construction 3 separated from filter can 4, and with air cleaner element 21 removed from can 4.

For the particular arrangement shown, air cleaner element 21 is generally cylindrical. Element 21 includes first and second end caps 23 and 24; filter media 25; inner support 26 (Fig. 4); and, outer support 27. For the particular embodiment shown, filter media 25 comprises a pleated paper construction 30. In general, pleated paper construction 30 comprises a cylinder 31 of fluted paper with the flutes running in a direction longitudinally along, and generally parallel to, a central axis 33 of the element 21. It will be understood that alternate filter media constructions could be utilized. In general, the filter media 25 extends between the end caps 23 and 24. For assembly 1 depicted, end caps 23 and 24 comprise polymeric material as described below, in which opposite ends of the filter media 25 are set or potted.

In Fig. 4 a fragmentary cross-sectional view of air cleaner assembly 1 is depicted. In Fig. 4, the inlet

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In general, end cap 23 is open and end cap 24 is closed. That is, end cap 23 includes a large inlet aperture 28 (Fig. 4) therein, for introduction of air to be filtered into filter element interior 35. End cap 24, on the other hand, is generally closed, but for a drainage aperture extending therethrough as described below.

15 Still referring to Fig. 4, it can be seen that inlet construction 3 includes inlet tube 14. When assembled, inlet tube 14 extends into aperture 28 in end cap 23. At least in this location, end cap 23 is preferably formed of a soft compressible material. When  
20 inlet tube 14 is not inserted into aperture 28, at least a portion of aperture 28 in its uncompressed state will generally have an inside diameter slightly larger than an outside diameter of section 39 of inlet tube 14; i.e., the portion of tube 14 which engages end cap 23 when  
25 arrangement 1 is operatively assembled. Thus, when inlet tube 14 is inserted through aperture 28, end cap material in region 40 will be compressed. In this manner a seal is formed at region 41. Such seals are described, for

[illegible]

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Another point of potential leakage of unfiltered  
15 air into clean air plenum 44 is presented by the location  
whereat inlet construction 3 engages filter can 4. This  
region is located generally at 50; i.e., where bolts 8  
secure inlet construction 3 to filter can 4. At region 50,  
inlet construction 3 is provided with an outwardly  
20 extending flange 52; and, can 4 is provided with an  
outwardly extending flange 53. Seal ring 54 is provided in  
extension around can 4, between flanges 52 and 53. Seal  
ring 54 is positioned at a location between bolts 8 and  
filter element 21. When bolts 8 are tightened, seal  
25 ring 54 will be compressed between flanges 52 and 53, i.e.,  
at a location between inlet construction 3 and filter  
can 4, providing a seal. Thus, air leakage into plenum 44,  
by passage between portions of can 4 and inlet



construction 3 is inhibited. Filter ring 54 may be a conventional O-ring type gasket.

Attention is now directed to Fig. 5, which is a cross-sectional view showing the "bottom half" or "opposite 5 end" of assembly 1 from the end whereat inlet

construction 3 is located. Referring to Fig. 5, reference numeral 60 generally designates an end of can wall 61.

Within end 60 is positioned a cover or base 63 of can 4.

Base 63 is configured in a preferred manner, to advantage.

10 For the particular embodiment shown, base 63 is circular, to conform to the cross-sectional configuration of can wall 61 at end 60. For the particular embodiment shown, base 63 is also radially symmetric. That is, the features of base 63 are configured radially symmetrically 15 about central axis 33. Base 63 includes end flange 65 for engagement with end 60, for example by means of welds.

Progressing inwardly from flange 65 toward its center 66, the features of the preferred base 63 depicted are as follows: an annular circumferential sealing 20 surface 67 is provided; a bend or corner 68; an end surface 69; a secondary seal bead or ridge 70; and, a central pan 71. In the center 66 of pan 71, drainage aperture 18 is provided.

The arrangement shown in Figs. 1-7 is configured 25 preferentially so that when oriented for use, pan 71 is at a lowermost or recessed location, so that water will drain to pan 71 under gravity influence. As the water drains into pan 71, it will be drained outwardly from air cleaner

5 Still referring to Fig. 5, filter element 21 includes end cap 24 thereon. End cap 24 is of an appropriate material, and of appropriate size, so that when it is pushed into and against base 63, an outer circumferential surface 75 of the end cap 24 engages  
10 surface 67 of base 63 in a sealing manner. That is, an annular seal 76 is formed in region 77, circumferentially around end cap 24. This is facilitated by preferably providing surface 67 in a cylindrical configuration extending generally parallel to axis 33. The seal prevents  
15 unfiltered air from reaching clean air plenum 44. As a result of the circumferential seal, sealing against flow of air is not required between any other portions of filter element 21 and base 63. A secondary seal 80, described herein below, is provided, however, between end cap 24 and  
20 base 63. The secondary seal 80 is generally provided to inhibit movement of debris or water into region 81, between element 21 and base 63, rather than to necessarily prevent flow of air therebetween. Thus, while seal 76 should be in a form sufficient to withstand a pressure differential  
25 thereacross of up to about 40 inches of H<sub>2</sub>O, secondary seal 80 will generally be sufficient if it can maintain at pressure differential thereacross of up to about 2 inches (and typically only up to about 2-4 inches) of H<sub>2</sub>O.

Still referring to Fig. 5, end cap 24 includes a circular recess or trough 85 therein. Trough 85 is sized and configured to receive and sealingly engage bead 70. Trough 85 should be sized, relative to bead 70, such that when element 21 is pressed against base 63, bead 70 is pushed into trough 85 to form a seal therewith, capable of holding a pressure differential of up to about 2-4 inches of H<sub>2</sub>O. This could be readily accomplished by forming the related region 86 of end cap 24 of an appropriately soft compressible polymeric material into which rigid bead 70 can be pressed, for engagement.

Referring to Figs. 5 and 6, it is noted that for the preferred embodiment depicted surface 90 of end cap 24 is recessed from outer edge 91 to region 92, so that a space between surface 90 and end surface 69 is provided, when filter element 21 is operatively positioned within can 4. The amount of recess can be varied, depending upon the size of the arrangement. In general, an angle of inclination from edge 91 to region 92 on the order of about 1° to 3° will be sufficient.

Advantages which result from this inclination, will be apparent from further descriptions herein below. In general, the space between surface 90 and end surface 69 ensures that there will not be interference with easy formation of the annular, radial, seal.

Still referring to Figs. 5 and 6, internal surface 94 of end cap 24 is configured to slope downwardly, when the assembly 1 is oriented as shown in Figs. 5 and 6,

In some embodiments, recessed radial troughs extending outwardly and upwardly from central aperture 96 can be used to facilitate this flow. Such an arrangement is shown, for example, in Fig. 7 (a top plan view of element 21) wherein 10 four evenly (radially) spaced, recessed, troughs 99 are depicted. It will be understood that each of troughs 99 generally inclines downwardly as it extends from region 95 toward central aperture 96, to facilitate collection of water within interior 35 and direction of the collected 15 water to central aperture 96. An advantage to troughs 99 is that should a leaf or other large particulate material become positioned over central aperture 96, water can still flow into and through the aperture 96 by means of the troughs 99, since the troughs 99 can generally direct water 20 flow underneath debris collected on top of internal surface 94.

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cap 24 positioned beneath inlet tube 14. Water collecting on internal surface 95 will generally be directed toward central aperture 96, for drainage into recessed pan 71 and eventually drainage outwardly from assembly 1 through 5 drainage aperture 18. Evacuation valve 19, if used, will facilitate this.

Because sealing between end cap 24 and housing 2 is positioned along annular circular sealing surface 67, i.e., at region 77, the critical sealing is not located at 10 a surface where debris is likely to be spread or collect, as element 21 is removed from and replaced into housing 2, during typical maintenance operations.

Because surface 90 is recessed from end surface 69, in extension between edge 91 and region 92, any 15 debris which may spread along end surface 69 during operations involving removal and insertion of filter elements into housing 2, will not likely interfere with sufficient insertion of the element 21 into can 4 for the development of a good seal at region 77. That is, some 20 debris buildup along the bottom of base 63 is well tolerated.

Also, secondary seal 80 will inhibit the likelihood of debris or moisture moving from pan 71 into surface 69, or region 77. This will also help facilitate 25 removal of moisture from assembly 1, since the moisture will tend to concentrate near drainage aperture 18.

In Fig. 6, the arrangement of Fig. 5 is shown exploded. From this, a preferred configuration for

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surface 75, relative to circular (annular) sealing surface 67 will be understood. In particular, surface 75 includes steps 101, 102 and 103, with extensions 105 and 106 therebetween. Step 103 is approximately the same diameter as circular sealing surface 67, and facilitates guidance of air cleaner element 21 into engagement with base 63, during assembly. Step 102 is preferably slightly larger in diameter than circular sealing surface 67, and step 101 is preferably slightly larger in diameter than step 102, to enhance compression of end cap material in region 77, as element 21 is inserted into base 63, during assembly. In this manner, a good seal is formed. In general, for preferred embodiments the actual amount of compression of the end cap in region or step 102 is  $3 \text{ mm} \pm 1 \text{ mm}$  on diameter (or  $1.5 \text{ mm}$  at any location). The diameter of step 102 is preferably about  $1.5 \text{ mm}$  greater than step 101, and about  $3 \text{ mm}$  greater than step 103. The amount of compression in step 102 would preferably be about  $21.4\%$  ( $20\% \pm 3\%$ ).

As indicated, the arrangement described with respect to Figs. 1-7 generally utilizes a radial seal engagement in region 77. Alternate sealing arrangements may be utilized. An example of such an arrangement is illustrated in the alternate embodiment of Fig. 8.

In Fig. 8 an alternate application of principles according to the serial no. 08/742,244 disclosure is provided. Fig. 8 illustrates an engagement between an air cleaner assembly base and a filter element, to provide

advantages according to the present invention, in an arrangement which utilizes an "axial seal" between the filter element and the housing, at least at this location.

In general, an axial seal is a seal which is maintained by forces directed along an axis of the filter element, as opposed to radial seal arrangements described with respect to Figs. 1-7 which use forces directed radially around an axis. Axial seal arrangements have been widely utilized in filter elements in a variety of manners. Often a central yoke or axle is provided, along which forces are directed between the housing in the element. In other systems a bolt engagement between portions of the housing are used to compress the element against one end or both ends of the housing. The O-ring 54 in the embodiment of Figs. 1-7, for example, provides sealing by axial compression.

Fig. 8 is a fragmentary cross-sectional view of an alternate air cleaner assembly 115. The air cleaner assembly 115 is also a reverse flow arrangement. Assembly 115 includes housing 116 and air filter element 117. An inlet arrangement, not depicted, would be utilized to direct air flow into interior 118. Air flow would then be through filter element 117 into clean air plenum 120, and outwardly through a conventional outlet, not shown, into an air intake for an engine.

In Fig. 8 the outer wall of the housing 116 or can, is generally shown at 121. The housing end or base

123 is configured to perform functions generally analogous to those for base 63, Figs. 1-7.

Still referring to Fig. 8, filter element 117 has a sheet metal end cap, such as end cap 125. The filter element 117 includes filter media 126 potted within the end cap 125 (the opposite end cap not being shown in Fig. 8). Element 117 includes inner and outer liners 127 and 128 respectively.

Sealing between element 117 and base 123, against air flow therebetween, is provided by gasket 130. That is, an appropriate mechanism to apply axial forces in the direction of arrow 131 against element 117 should be provided, to compress gasket 130 between end cap 125 and base 123 and form a seal. This can be accomplished with bolts used to drive an end cover or inlet construction against an opposite end of element 117. Preferably appropriate sizes and configurations of the element 117, base 123 and gasket 130 are selected, so that the seal of gasket 130 will be sufficient to hold a pressure differential at least about 40 inches of H<sub>2</sub>O thereacross. In this manner, unfiltered air in region 132 is prevented from reaching clean air plenum 120, in use.

In general, the features of the preferred base 123 depicted are as follows. Base 123 is radially symmetric and includes outer flange 135, for securement to can wall 121, such as by welding. Base or recess area 136 is provided for a receipt of gasket 130 therein, during sealing. This is accommodated by recessed area 136 forming

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A secondary seal between end cap 125 and surface 10 139 is provided by secondary seal gasket 155. This gasket 155 is intended to inhibit the migration of moisture and debris from recessed pan 145 into region 137, whereat it could interfere with seal gasket 130. Secondary gasket 155 need only provide a seal sufficient to inhibit substantial 15 migration of moisture and debris, and does not need to be a primary air seal. Thus, gasket 155 need only be compressed sufficiently to withstand a pressure differential of up to about 2-4 inches of H<sub>2</sub>O thereacross.

Operation of assembly 115 will now be apparent.

20 When assembled, sufficient axial pressure is applied along the direction of arrow 131, to provide an air seal end at gasket 130 and a secondary seal at gasket 155. Debris and moisture directed into interior 118 will generally collect in pan 150. In general, moisture collecting along recessed

25 surfaces 149 will be directed downwardly toward and through aperture 151, into pan 145 of base 123, and eventually through drainage aperture 147 and outwardly from assembly 115. It will be understood that a trough system (analogous

to that described for Figs. 1-7) may be utilized in pan 150, if desired, to inhibit the likelihood of drainage aperture 151 becoming closed or plugged by debris.

5 **Materials Described in Serial No. 08/742,244**

According to Serial No. 08/742,244, while a wide variety of materials may be utilized in the constructions, the principles described were particularly developed for use, to advantage, with systems constructed from certain 10 preferred materials. In general, the constructions were designed for utilization with sheet metal housing systems, or stainless steel housing systems; i.e., arrangements wherein the housing, in particular the inlet assembly, the can and the base, are formed from sheet metal or stainless 15 steel parts which are secured to one another as by welding.

Materials useful for such fabrication include 0.075-0.025 (incorrectly stated as 0.75-0.25 in the earlier disclosures) inches thick stainless steel or sheet metal, although other thickness are useable. Plastics can also be 20 used.

For the arrangement of Figs. 1-7, the preferred end cap material described in serial no. 08/742,244 for forming the regions in the end cap that need to be compressed to form a seal is a soft polymeric material such 25 as foamed polyurethane. Such materials include the following polyurethane, processed to an end product having an as molded density of 14-22 pounds per cubic foot (lbs/ft<sup>3</sup>).

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- 1) total system = 1-5% carbon black
- (h) Blowing agent
  - 1) 0.1-6.0% HFC 134A.

5 The I3050U isocyanate description is as follows:

- (a) NCO content - 22.4-23.4 wt%
- (b) Viscosity, cps at 25°C = 600-800
- (c) Density = 1.21 g/cm<sup>3</sup> at 25°C
- (d) Initial boiling pt. - 190°C at 5mm Hg
- 10 (e) Vapor pressure = 0.0002 Hg at 25°C
- (f) Appearance - colorless liquid
- (g) Flash point (Densky-Martins closed cup) = 200°C.

The materials I35453R and I3050U are available  
15 from BASF Corporation, Wyandotte, Michigan 48192.

For the arrangement shown in Fig. 8, the filter element includes sheet metal end caps with a fluted filter paper media element potted therein. Conventional arrangements such as potted in plastisol may be used.

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**Dimensions of a Typical Embodiment**  
**Described in Serial No. 08/742,244**

Consider an air cleaner arrangement such as depicted in Fig. 1 used on a over the highway truck (heavy  
25 duty truck). The housing would be about 13-15 inches in diameter and about 32 inches long. The element would be about 11-13 inches in diameter and about 23-26 inches long.  
The I.D. of the smallest rib on the sealing portion of the

end cap with the inlet tube (prior to compression) would be about 6.78-7.44 inches. The I.D. of the annular surface in the housing base whereat the radial seal with second end cap occurs would be about 11.28-12.94 (incorrectly stated as 19.94 in serial no. 08/742,244) inches. The O.D. of the largest step on the second end cap, for sealing with the base, would be about 11.4-13.06 inches. The bead on the base for engagement with the second end cap would be large enough to extend into the trough on the end cap about 0.35 10 inches. The declination angle in the second end cap from its outer rim to the recess engaging the bead would be about 1.75°. The declination angle on the inside of the second end cap would be about 4°±2°.

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**Description Added to Disclosure of**  
**Serial No. 08/742,244**

It is first noted that there has been developed a preference for application of the techniques described in Serial No. 08/742,244 since the time of filing of that 20 application. In particular, it is desirable, when molding end cap 24, to provide for a media stand-off to ensure that the media 25 is supported above a remaining portion of a bottom surface of the mold, when the molding occurs. The mold can be provided with a circular, raised, media stand- 25 off positioned in a portion of the mold underneath the media 25, during molding, to provide for this. The end cap 24 would, in general, show an indent ring corresponding to

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A principal difference for the embodiment of Figs. 9-14, from the embodiment of Figs. 1-7, concerns the referenced insert and the specifically recited composite

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Still referring to Fig. 9, filter element 221 includes end cap 224 thereon. End cap 224 comprises an appropriate material, and is of appropriate size, so that when it is pushed into and against base 263, an outer  
25 circumferential surface 275 of the end cap 224 engages surface 267 of base 263 in a sealing manner. That is, an annular seal 276 is formed in region 277, circumferentially around end cap 224. As with the embodiment of Fig. 5, this

is facilitated by preferably providing surface 267 in a cylindrical configuration extending generally parallel to axis 233. As a result of the circumferential seal 276, sealing against flow of air is not required between any other portions of filter element 221 and base 263. A secondary seal 280, analogous to seal 80, Fig. 5, is provided, however, between end cap 224 and base 263. The secondary seal 280 inhibits movement of debris or water into region 281, between element 221 and base 263.

10 It is noted that the particular configuration of outer circumferential seal surface 275 of end cap 224, for the arrangement shown in Fig. 9, differs from the analogous surface 67 in the embodiment of Fig. 5. A preferred configuration for surface 267 (and surface 67 if applied in 15 the embodiment of Fig. 1) is described hereinbelow in connection with the mold Fig. 13.

Still referring to Fig. 9, end cap 224 includes a circular recess or trough 285 therein. Trough 285, analogously to trough 85, Fig. 5, is sized and configured 20 to receive and sealingly engage bead 270. Trough 285, which, in the preferred embodiment depicted has somewhat of an inverted "V" configuration (with a rounded apex) when viewed in cross-section, should be sized, relative to bead 270, such that when element 221 is pressed against 25 base 263, bead 270 is pushed into trough 285 to form a seal therewith, capable of holding a pressure differential at least up to about 2-4 inches of H<sub>2</sub>O.

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Analogously to end cap 24 of the arrangement shown in Fig. 5, end cap 224 comprises a soft, polymeric material. However, unlike end cap 24 shown specifically in Fig. 5, end cap 224 is a composite. In particular, end cap 224 comprises: section 399 of compressible, polymeric material 400; and, insert 401. Advantages which result from the provision of the insert 401, as part of the end cap 224, will be apparent from further descriptions hereinbelow.

10 A more detailed description of the manner of construction, to provide insert 401, is also provided hereinbelow. In general, the insert 401 is secured to the "filter pack" which would typically comprise media 225 (which is pleated paper in the preferred embodiment shown),  
15 inner support 226, and outer support 227. Supports 226 and 227 could comprise, for example, conventional perforated metal or expanded metal media liners. Inner liner 226 defines inner chamber 235 (which is cylindrical in the preferred embodiment shown). During assembly, after the  
20 filter pack comprising the liners 226, 227 and media 225 is prepared, insert 401 would be positioned in one end of that filter pack, closing an end 235a of chamber 235. The assembly comprising a filter pack and insert would then be potted within the polymeric material which is then cured to  
25 form material 400, Fig. 9. In a typical operation, this potting would be achieved by positioning the filter pack and insert 401 in an appropriate mold and distributing within the mold the uncured polymeric material, which is

Attention is now directed to Figs. 10 and 11 in which the details of the preferred insert 401 are depicted in detail, and from which advantages which result from utilization of the insert 401 can be understood. Referring first to Fig. 10, which is a top plan view of the insert 401, the insert 401 has an outer perimeter 410 (circular in the preferred embodiment shown) with depending legs 411. The specific insert 401 depicted in Fig. 10 includes twelve evenly radially (i.e., separated radially by 30°) spaced legs 411, each of which terminates in a foot 412. Of course, alternate numbers and specific configurations of legs 411 and feet 412 may be used.

In general, upper surface 415 of insert 401 will, 25 when element 221 is assembled, generally comprise the inner surface of composite end cap 224. Thus, surface 415 will include thereon the inner drainage surface for directing fluid to central aperture 296 in element 224.

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Troughs 429 are also identical to one another and are separated radially by 90°. Each one of troughs 429 is evenly spaced between two adjacent ones of troughs 428. Each of troughs 429 and 428 comprises a pair of ridges 425.

5           Troughs 428 differ from troughs 429 in that troughs 428 are longer; that is, troughs 428 extend a greater percentage of the distance toward aperture 422 from perimeter ridge 420. Troughs 429 are shorter (in elongated extension), primarily in order to leave open spaces 431 for  
10 liquid flow on surface 415 toward aperture 422.

Between the ridges 425 defining any given trough, 428, 429, an aperture hole through insert 401 is provided. Thus, there are two sets of apertures: apertures 433 in troughs 428; and, apertures 434 in troughs 429.  
15 Apertures 433 and 434 are generally oval-shaped, and act as free rise apertures to allow for free rise of polymeric material 400 therethrough, during the molding process. This helps secure the insert 401 as part of the composite end cap 224. It also facilitates a controlled molding  
20 process, as described below. The ridges 425 help contain the rising polymeric material 400, during the molding process, in part to maintain substantial portions of surface 415 open, for free fluid flow thereacross.

Note that as a result of the ridges 425 being  
25 raised above surface 415, improvement in liquid flow across surface 415 is provided. This is in part because leaf material, paper material, etc., which settles into

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Preferably an outer radius defined by the  
10 perimeter of the legs at regions 430, is slightly larger  
than the inner dimension (diameter) of liner 235; and,  
legs 411 are sufficiently thin to flex inwardly somewhat,  
when pressed into an end of inner liner 235, during  
assembly. This "spring" effect can be used to temporarily  
15 secure insert 401 to liner 235 in the filter pack, during  
the molding operation, as described below. Preferably, the  
outer radius of the legs at regions 430 is about 0.25  
inches.

Each leg 411 includes a tapered rib 413 extending 25 therefrom. Each rib 413 extends from just above an upper surface 441 of each foot 412 to just below the radiussed surface 430. Ribs 413 help to temporarily secure insert 401 to liner 235 in the filter pack, during the

molding operation, as described below. Preferably, each rib 413 is about 60 thousandths of inch thick, and extends a length of about 0.3 inches. Each rib 413 extends about 1° from vertical.

5                    Still referring to Fig. 11, each foot 412 includes a bottom bead 440 thereon. The bottom bead 440 operates as a mold stand-off, during molding. In particular, bottom beads 440 will support a remainder of insert 401 above a lower surface of a mold, during a  
10 molding operation, to help ensure that a remainder of insert 401 will be embedded within the resin, during the molding operation. After molding, beads 440 will either be slightly exposed in the molded end cap, or they will be covered by a thin layer of molded material, depending upon  
15 the molding operation. Either condition is acceptable. Preferably, each bead 440 extends at a radius of about 0.06 inches.

Each foot also includes an upper surface 441. The upper surface is preferably at least 0.375 inches long,  
20 and, during assembly, will extend beyond the filter pack inner liner 235 to positions underneath the filter media 225. As a result of being positioned underneath the filter media 225 during assembly with a filter pack, upper surfaces 441 of the feet 412 will operate as media stand-  
25 offs, during molding. This will prevent the media 225 from dropping all the way to the bottom of the mold cavity.

Still referring to Fig. 11, attention is directed to a portion of surface 416 which circumscribes

aperture 422. That portion or region is indicated generally at reference numeral 450. Within this region is located a circular trench 451. (Circular when viewed in bottom plan view.) The circular trench 451 preferably has a semi-circular cross-section as shown in Fig. 11, although alternative configurations can be used. During the molding operation, trench 451 will be aligned with, and receive, a bead in the mold. This will inhibit, during molding, flow of resin along the direction indicated generally by arrows 452, past surface 450 and into aperture 422. The result will be an inhibition of polymeric flash at, or in, aperture 422.

As a result, it is anticipated that after a molding operation, certain portions of surface 450, indicated generally at 455 between trough 451 and aperture 422, will generally be exposed, except perhaps for some small amount of flash from the molding operation. The exposed surface 455 is viewable in Fig. 14, a bottom plan view of element 221.

Advantages to a composite end cap 224 including an insert such as that shown in Figs. 10 and 11, result from at least two related concerns. First, it is anticipated that insert 401 will typically be manufactured from a material that can be molded, for example a molded, rigid, polystyrene or similar material. As a result of such a molding, specific configurations can be readily provided to surface 415 to achieve advantageous fluid flow effects and similar effects without relying upon control of

In addition, the molding process to provide for polymeric material 400 is facilitated. This is because a "closed mold" process is not required. Rather, free rise of the polymeric material 399 is accommodated because

10 insert 401, including apertures 433 and ridges 425, will control and direct rise. The free rise will not effect the downward slant in regions 421, to achieve a desirable drainage effect in insert 401, since the inner surface 415 of the end cap 224 is pre-formed.

15 In general, when the end cap 424 comprises a  
composite of an insert 401 and polymeric material 400 as  
described herein, the polymeric material may comprise the  
preferred polyurethane described in application serial no.  
08/742,244, and previously herein, molded end or similar  
20 conditions.

However, preferably the urethane comprises a material made with Elastofoam I36070R resin and Elastofoam I3050U isocyanate as described below. The material should be mixed as described above, except with I36070R, replacing 25 the I35453R resin. For this material, the mold temperature should preferably be about 105°-150°F.

The resin material I36070R has the following:

(a) Average molecular weight



- 1) Base polyether polyol = 500-15,000  
2) Diols = 60-10,000  
3) Triols = 500-15,000  
(b) Average functionality  
5 1) total system = 1.5-3.2  
(c) Hydroxyl number  
1) total systems = 100-300  
(d) Catalysts  
1) amine = Air Products 0.1-3.0 PPH  
10 (e) Surfactants  
1) total system = 0.1-2.0 PPH  
(f) Water  
1) total system = 0.03-3.0 PPH  
(g) Pigments/dyes  
15 1) total system = 1-5% carbon black  
The Elastofom I3050U isocyanate description is  
as follows:  
(a) NCO content--22.4-23.4 wt. %  
(b) Viscosity, cps at 25°C = 600-800  
20 (c) Density = 1.21 g/cm<sup>3</sup> at 25°C  
(d) Initial boiling pt.--190°C at 5 mm Hg  
(e) Vapor pressure = 0.0002 Hg at 25°C  
(f) Appearance--colorless liquid  
(g) Flash point (Densky-Martins closed cup) =  
25 200°C

The materials Elastofom I36070R and Elastofom I3050U are available from BASF Corporation, Wyandotte, Michigan 48192.

With respect to the liner material, no particular preference is made. In general, it is foreseen that the liner will comprise either perforated metal or expanded metal, for example G60 galvanized steel, having a thickness of about 0.03 inches. Such liners are commonly used in other types of large filter elements for trucks, for example.

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Referring to Fig. 12, a filter pack is indicated generally at 500. The filter pack comprises outer liner 227, media 225, and inner liner 226. The filter pack 500 is shown aligned to receive insert 401 therein, with feet 411 positioned under media 225, and with a remainder of insert 401 positioned within inner chamber 235. The combination of filter pack 500 and insert 401 would then be positioned within mold 501. The appropriate resin mix would be positioned in the mold as well, and cured. Again, free rise conditions for curing are allowable, due in part to the design of insert 401.

Attention is directed to Fig. 13, which indicates a schematic cross-section of a usable mold 501. Note the mold includes bead 502 for engagement with trough 451 in insert 401, Fig. 11, discussed above. Center post 503 fits through aperture 422 in insert 401, and ensures a proper positioning as well as inhibition of flash within the aperture 422. Note the positioning of bead 504, which will generate trough 285, Fig. 9. Also note the positioning of stand-off 505, which is formed as a ring in mold 501. Stand-off 505 will receive beads 440 positioned thereon, during molding. This is illustrated in Fig. 15, schematically, in which insert 401 is shown positioned within mold 501.

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The standing ribs or ridges 425 on the insert would have a height of about 0.077 inches, and a thickness at a distal end (free end) of about 0.042 inches. Each of the ridges 425 between the base proximate to the regions 421 and the free end would be curved on a radius of about 0.062 inches. The distance between a pair of free ends of two of the ridges would be about 0.4 inches. Apertures 433

and 434 would have radii at each respective end of about 0.125 inches.

Circular trench 451 would have a semi-circular cross-section. The radius of the cross-section would be about 0.031 inches. The diameter of circular trench 451 would be about 0.736 inches.

The diameter for the insert extending from the outermost end tip of one of the feet to the outermost end tip of a diametrically opposite foot would be about 9.265 inches. The diameter of the insert extending from the outermost part of one of the legs (not including the foot) to the outermost part of a diametrically opposite leg (not including the foot) would be about 8.515 inches. The inner radius of each leg 411 as it bends from a top surface of the insert down toward its foot would be about 0.187 inches. The outer radius of each leg 411 as it bends from a top surface of the insert down toward its foot would be about 0.25 inches. The radius of each leg 411 as it bends from its substantially vertically extension to its foot would be about 0.03 inches. The radius of each bead 440 would be about 0.06 inches. The angle of declination at ramp section 453 would be about  $30^\circ$  from horizontal, and on a radius of about 0.125 inches.

Each rib 413 on legs 411 would be about 60 thousandths of inch thick, and extend a length of about 0.3 inches. Each rib 413 would extend about  $1^\circ$  from vertical. Each leg 411 would extend at an angle of about  $5^\circ$  from vertical, and be about 0.625 inches long in extension

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